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AIR FORCE RESEARCH LABORATORY

Characterization of Horizontal Impulse Accelerator Pin Profiles

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AIR FORCE RESEARCH LABORATORY

September 2005

Interim Report for February 2005 to May 2005

Approved for public release; distribution is unlimited.

Human Effectiveness Directorate
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NOTICE

TECHNICAL REVIEW AND APPROVAL

AFRL-HE-WP-SR-2006-0057

THIS TECHNICAL REPORT HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION.

FOR THE DIRECTOR

//SIGNED//

MARK M. HOFFMAN
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14. ABSTRACT
Tests were run on the AFRL/HEPA Horizontal Impulse Accelerator (HIA) to document the dynamic response of 31 available metering pins. These interchangeable pins regulate the flow of gas through the HIA and produce an acceleration pulse unique to each pin. The standard 40G seat was used with a VIP-95 manikin test subject. Data collected were Sled X, Y, and Z accelerations, impact rise time, impact duration, velocity change, and onset rate. HIA operating parameters were also documented for each pin.

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PREFACE

An experimental effort was conducted to document the dynamic response characteristics of 31 metering pins currently available for use on the Horizontal Impulse Accelerator. These interchangeable pins regulate the flow of gas through the Horizontal Impulse Accelerator and produce an acceleration pulse profile unique to each pin. Characteristics documented in this report include impact rise time, impact duration, velocity change, sled acceleration, and onset rate. Approximate operating parameters for each pin are also included.

The tests described within this report were accomplished by the Biomechanics Branch, Biosciences and Protection Division, Human Effectiveness Directorate of the Air Force Research Laboratory (AFRL/HEPA) at Wright-Patterson AFB, Ohio.

The impact facilities, data acquisition equipment, and data processing system were operated by General Dynamics under ALSTAR Contract FA8650-04-D-6472.

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INTRODUCTION

Background

When a researcher wants to use the Horizontal Impulse Accelerator (HIA), the first step is to determine the acceleration pulse characteristics required. This information is then passed on to the facility engineer who uses a computer program to determine the HIA operating parameters that will meet those requirements. The process is iterative and only gives an approximation of both the parameters required and the resulting acceleration pulse characteristics.

Few of the available HIA pins appear in the Biodynamic Data Bank (a web-based repository of data collected on each HIA test).

It would be much more efficient if investigators had a handy reference presenting the full range of HIA capabilities they could refer to which would allow them to quickly see if the HIA could meet their requirements.

Test Objectives

The specific objective of this study was to determine and document the operating characteristics for each of 31 available pins at commonly used acceleration levels.

The operating characteristics documented for each pin include velocity change, rise time, pulse duration, onset rate, and approximate HIA operating parameters.

METHODS

Test Facilities and Equipment

The Horizontal Impulse Accelerator (Shaffer, 1976) was used for all tests. The HIA consists of a gas operated actuator, a test sled, and track rails as shown in Figure 1. The actuator produces forward thrust through differential gas pressures acting on opposite faces of a thrust piston in a closed cylinder. The cylinder is divided by an orifice plate into a rear or load chamber and a front or set chamber. Prior to firing, a low gas pressure (relative to the rear chamber pressure) forces the thrust piston against a seal ring on the orifice plate. The full area of the front of the thrust piston is exposed to the front chamber pressure, while only the relatively small area within the seal ring on the rear of the thrust piston is exposed to the high pressure in the rear chamber. The system is stable in this condition as the net force on the piston is acting rearward so as to maintain the seal. At firing, high pressure gas is introduced between the orifice and the rear of the thrust piston upsetting the seal. At this point the full area of the rear of the thrust piston is exposed to the high pressure gas in the rear chamber producing a large net forward force on the thrust column and sled combination. By controlling the manner in which the gas is metered through the orifice into the thrust chamber (the purpose of the pins tested in this study), the stroke length and the initial pressures, the resulting force and the acceleration imparted to the sled can be altered and controlled. Emergency brakes are used to stop the sled after the acceleration pulse is imparted to it. It is also possible to reduce the rise time of the acceleration pulse by applying glide brakes from the start of impact.

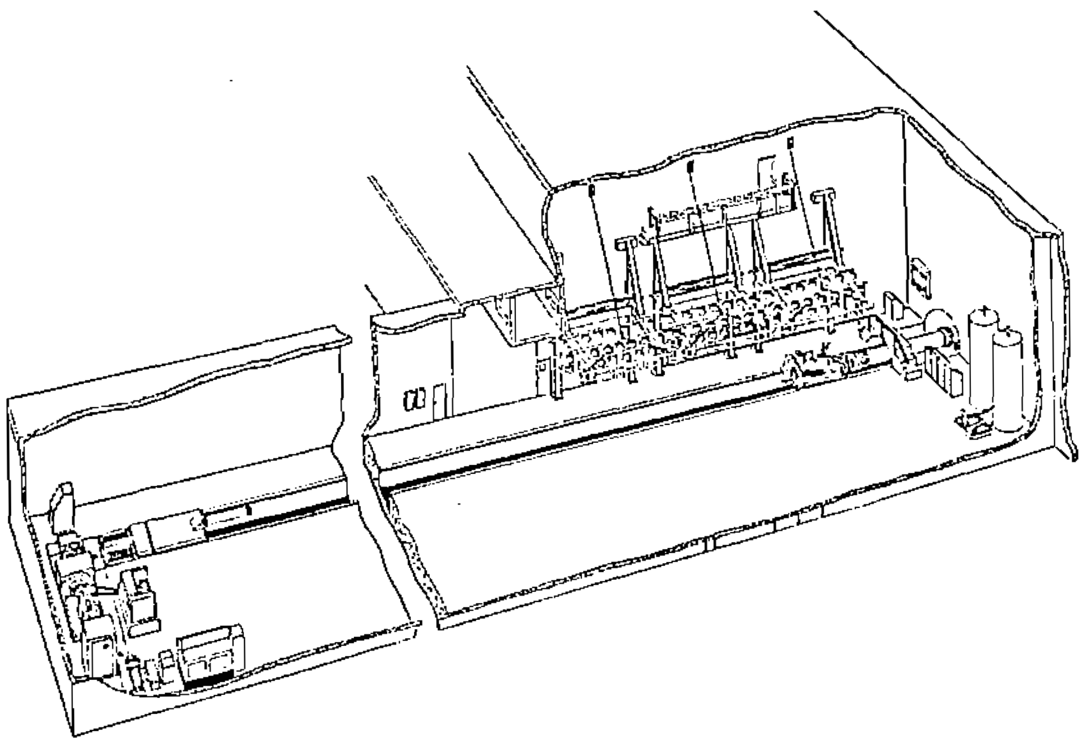

Figure 1. Horizontal Impulse Accelerator

The standard 40 G seat was used for all tests (see Figure 2). Since the manikin and seat are un-instrumented and only the sled response is of interest, the seat was oriented to have the manikin facing down track. This avoids the danger of catastrophic restraint failure at high G levels. A VIP-95 manikin was used as biofidelity was unimportant. The manikin was restrained with a PCU-15/P harness. A manikin and standard seat were used to give the sled the total weight characteristics seen in a typical test program. This is important because the payload weight affects HIA performance.

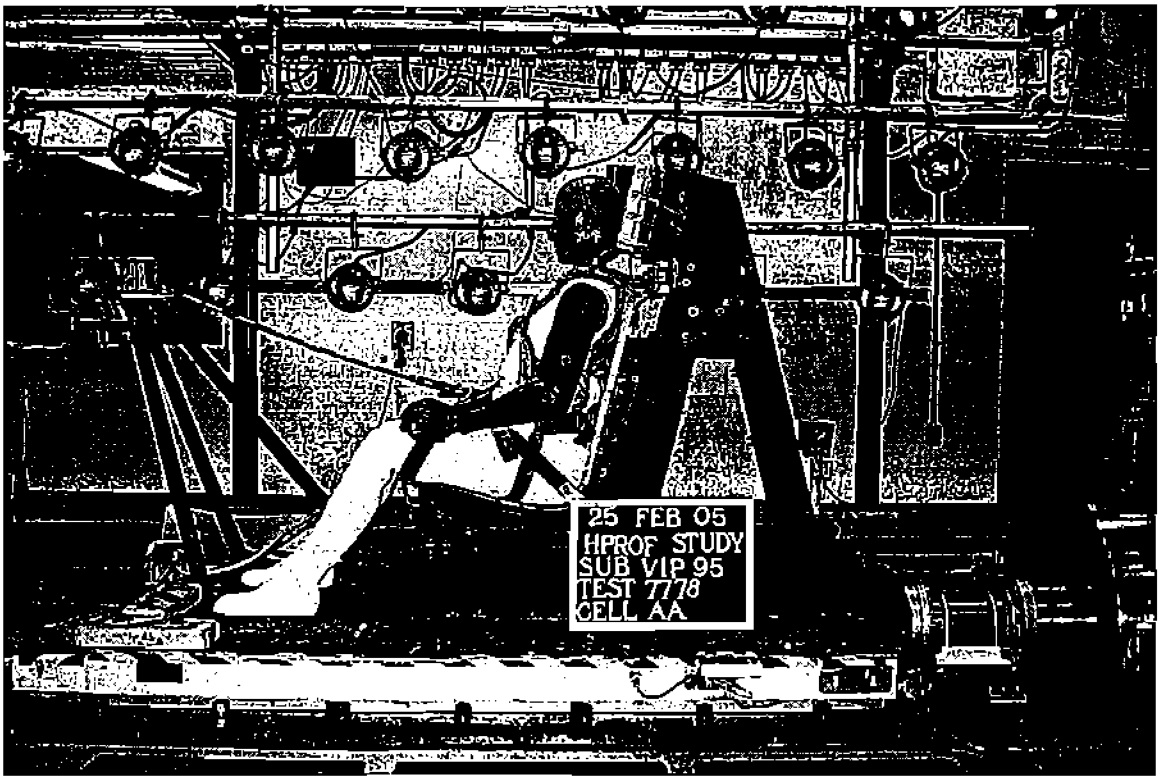

Figure 2. Seat and Manikin

Instrumentation and Data Processing

The only instrumentation used in the tests was a triaxial accelerometer mounted to the sled. A right-handed coordinate system was used with the +X axis pointing down track and the +Z axis pointing upward. Transducer signal processing was provided onboard the sled by the EME DAS data acquisition system. Sampling for all channels was 1,000 samples per second. All channels were filtered at 120 Hz with a five-pole Butterworth software filter.

Experimental Design

Table 1 shows the test matrix for this program. Cells were normally repeated until the peak X axis acceleration of the sled met the requirement with a tolerance of ±4%. Some pins showed an erratic response, were of marginal utility, or posed some risk of damage to the facility due to high G level (Cells A, E, F, G, H, I, K, L, R, S, OO, QQ, RR, SS, UU). The tolerance requirement was relaxed for these. In the same way some tests that were outside the tolerance band by a very small amount were accepted due to time constraints.

In Table 1, a high G pin is one that can be used for tests above about 15G, while the remainder are low G pins generally used for tests below 15G. R.T. is the measured rise time of the acceleration pulse in ms, and DUR.is the measured duration of the acceleration pulse. Some pins can be used to represent a sinusoidal pulse or a sawtooth pulse as required. This is indicated in the table. Two cells (CC and HH) were not run due to minimal utility. They were intended to be the minimum possible acceleration pulse duration for pins designed for and used exclusively to achieve very long pulse durations. They are noted here only because they appear in the test plan.

Table 1. Test Matrix

CELL	PIN	PEAK G	PROFILE	NOTES
A	1	10	SINE	HIGH G PIN
B	1	20	SINE	HIGH G PIN
C	1	30	SINE	HIGH G PIN
D	1	40	SINE	HIGH G PIN
E	2	10	TRAPEZOIDAL	HIGH G, MAX DURATION
F	2	20	TRAPEZOIDAL	HIGH G, MAX DURATION
G	2	30	TRAPEZOIDAL	HIGH G, MAX DURATION
H	2	40	TRAPEZOIDAL	HIGH G, MAX DURATION
I	3	30	CRASH PULSE	VW PIN, R.T.=60, DUR=126
J	3	20	CRASH PULSE	VW PIN, R.T.=65, DUR=134
K	3	10	CRASH PULSE	VW PIN, R.T.=71, DUR=140
L	4	10	TRAPEZOIDAL	MAX DURATION
M	4	10	TRAPEZOIDAL	MIN DURATION
N	5	10	SAWTOOTH	MIN DURATION
O	5	10	SAWTOOTH	MAX DURATION
P	6	10	ACESII CATAPULT	MIN DURATION
Q	6	10	ACESII CATAPULT	MAX DURATION
R	2	30	TRAPEZOIDAL	HIGH G, MIN DURATION
S	24	10	ACESII CATAPULT	MIN DURATION
T	24	10	ACESII CATAPULT	MAX DURATION
U	22	20	CRASH PULSE	MIN DURATION
V	22	20	CRASH PULSE	MAX DURATION
W	7	10	SINE (SAWTOOTH)	R.T.=9, DUR=35
X	8	10	SINE	R.T.=22, DUR=50
Y	9	10	SINE	R.T.=30, DUR=87
Z	10	10	SINE	R.T.=35, DUR=87

Table 1. Test Matrix (continued)

CELL	PIN	PEAK G	PROFILE	NOTES
AA	11	10	SINE	R.T.=74, DUR=157
BB*	12	10	SINE	R.T.=117, DUR=248
CC				NOT RUN
DD	14	10	SINE (SAWTOOTH)	R.T.=14, DUR=78
EE	15	10	SINE (SAWTOOTH)	R.T.=16, DUR-89
FF	16	10	SINE	R.T.=20, DUR=84
GG	17	10	SINE	R.T.=23, DUR=87
HH				NOT RUN
II*	19	10	SINE	R.T.=110,DUR=201
JJ	20	10	SINE (SAWTOOTH)	R.T.=15, DUR=88
KK	21	10	SINE (SAWTOOTH)	R.T.=16, DUR=88
LL	23	10	SINE	R.T.=82, DUR=165
MM	13	10	SINE (MAX DURATION)	R.T.=160, DUR=249
NN	18	10	SINE (MAX DURATION)	R.T.=160, DUR=248
OO	51	10	SINE (SHORTENED PIN 11)	R.T.=55, DUR=99
PP	52	10	SINE (SHORTENED PIN 12)	R.T.=112, DUR=205
QQ	53	10	SHORTENED PIN 13	R.T.=7, DUR=127
RR	62	10	SHORTENED PIN 52	R.T.=61, DUR=105
SS	63	10	SHORTENED PIN 53	R.T.=8, DUR=128
TT	73	10	SINE (SHORTENED PIN 23)	R.T.=77, DUR=161
UU	74	10	(SHORTENED PIN 74)	R.T.=63, DUR=107
VV	9	6	SINE	R.T.=32, DUR=105
WW	10	6	SINE	R.T.=38, DUR=105
XX	11	6	SINE	R.T.=82, DUR=186
YY	19	6	SINE	R.T.=130, DUR=246
ZZ	23	6	SINE	R.T.=100, DUR=208

*Pins 12 and 19 are identical except for weight and have the same response. Cell BB is the maximum pulse duration and cell II is the minimum pulse duration for these pins.

RESULTS

HIA Test Numbers for Each Cell

Table 2 lists the HIA test numbers accepted as representative of the response of each cell from Table 1. This table is useful when accessing the Biodynamic Data Bank (Cheng et al, 2004), (www.biodyn.wpafb.af.mil, study 200501) for test information. Appendix A of this report contains plots of the acceleration profiles for each pin.

Table 2. Test Numbers Representative of Pin Performance for Each Cell

CELL	PIN	PEAK G	TEST NO.
A	1	10	7784
B	1	20	7789
C	1	30	7792
D	1	40	7794
E	2	10	7795
F	2	20	7796
G	2	30	7797
H	2	40	7799
I	3	30	7803
J	3	20	7802
K	3	10	7801
L	4	10	7817
M	4	10	7816
N	5	10	7812
O	5	10	7813
P	6	10	7815
Q	6	10	7814
R	2	30	7800
S	24	10	7871
T	24	10	7869
U	22	20	7807
V	22	20	7805
W	7	10	7893
X	8	10	7889
Y	9	10	7824
Z	10	10	7822

Table 2. HIA Test Numbers (continued)

CELL	PIN	PEAK G	TEST NO.
AA	11	10	7783
BB	12	10	7845
DD	14	10	7857
EE	15	10	7855
FF	16	10	7861
GG	17	10	7859
II	19	10	7838
JJ	20	10	7853
KK	21	10	7852
LL	23	10	7831
MM	13	10	7867
NN	18	10	7868
OO	51	10	7886
PP	52	10	7849
QQ	53	10	7865
RR	62	10	7877
SS	63	10	7864
TT	73	10	7884
UU	74	10	7873
VV	9	6	7826
WW	10	6	7820
XX	11	6	7781
YY	19	6	7833
ZZ	23	6	7828

HIA Operating Parameters

Table 3 shows the approximate HIA settings to achieve the test matrix performance requirements. Profile tests are still required for a test program to fine tune the operating parameters. In the last column of Table 3, emergency brakes, a (*) indicates that the glide brakes are charged to 50 psi (i.e., Cells G and H). All other cells do not use glide brakes.

Table 3. Approximate Operating Parameters to Achieve Cell Requirements

CELL	PIN	PEAK G	PIN LENGTH (IN)	SET PRESSURE (PSI)	LOAD PRESSURE (PSI)	SET LENGTH (IN)	LOAD LENGTH (IN)	EMER. BRAKES (PSI)
A	1	9	15	25	150	20	20	0
B	1	20	15	58	350	30	30	50
C	1	30	15	90	540	30	30	130
D	1	40	15	125	750	35	35	150
E	2	10	29.8	37	190	168	116	200
F	2	20	29.8	71	426	168	116	400
G	2	30	29.8	119	714	168	116	500*
H	2	40	29.8	170	1020	168	116	650*
I	3	30	21.2	93	560	104	104	350
J	3	20	21.2	58	345	76	76	125
K	3	10	21.2	32	190	50	50	50
L	4	10	32	35	210	160	116	80
M	4	10	32	40	240	40	40	0
N	5	10	3.8	21	126	10	10	0
O	5	10	3.8	20	120	160	116	50
P	6	10	28.4	67	400	36	36	0
Q	6	10	28.4	37	220	160	116	150
R	2	30	30	150	900	40	40	200
S	24	10	43.5	98	588	50	50	50
T	24	10	43.5	48	285	168	116	150
U	22	20	29	68	410	29	29	50
V	22	20	29	58	350	168	116	250
W	7	10	11	67	408	5	24	0
X	8	10	11	23	138	14	14	0
Y	9	10	11.3	25	150	16	16	0
Z	10	10	11.3	16	95	17	17	0

Table 3. HIA Operating Parameters (continued)

CELL	PIN	PEAK G	PIN LENGTH (IN)	SET PRESSURE (PSI)	LOAD PRESSURE (PSI)	SET LENGTH (IN)	LOAD LENGTH (IN)	EMER. BRAKES (PSI)
AA	11	10	53	36	216	59	59	40
BB	12	10	90	46	276	160	116	150
DD	14	10	11	21	126	12	17	0
EE	15	10	11	21	126	17	17	0
FF	16	10	11	24	142	17	17	0
GG	17	10	11	24	144	17	17	0
II	19	10	90	52	312	96	96	70
JJ	20	10	11	20	120	17	17	0
KK	21	10	11	20	120	17	17	0
LL	23	10	60	43	256	66	66	30
MM	13	10	90	99	594	168	116	150
NN	18	10	90	100	600	168	116	160
OO	51	10	14	48	288	20	20	0
PP	52	10	57	52	307	100	100	70
QQ	53	13	57	225	1350	63	65	100
RR	62	11	24	93	557	30	30	0
SS	63	7	24	102	612	30	30	30
TT	73	10	24	43	260	60	60	50
UU	74	11	28	133	800	34	34	50
VV	9	6	11.3	15	91	17	17	0
WW	10	6	11.3	27	165	16	16	0
XX	11	6	53	20	120	59	59	0
YY	19	6	90	27	163	96	96	25
ZZ	23	6	60	21	124	66	66	0

HIA Pin Response Characteristics

Onset rate, peak velocity change, rise time, and pulse duration were determined for each cell of Table 1. The results are shown in Table 4. These properties were calculated using the procedure described below.

To remove a constant offset from the impact profile, an average is computed for 200 ms starting at the reference mark time. The average is subtracted from the impact acceleration profile before computing the velocity change, rise time and onset rate. There was not enough time before the start of impact to average 200 ms for cells A, B, OO, and XX, so 25 ms was used instead. This problem was not detected until the test program was completed, causing the peak G for these cells to be outside the desired range. The pulse duration, calculated using an older subroutine, uses a 24 ms average for the offset instead of 200 ms.

The velocity change is calculated by integrating the X axis sled acceleration and tabulating the peak velocity.

To calculate the other pulse characteristics, the time is set to zero at the start of impact. The start of impact is the time on the rising side of the impact profile at which the G level is equal to 0.2 G. Since no time point is exactly 0.2 G, the closest time point less than 0.2 G is used. The G level must be greater than or equal to 0.2 G for five consecutive time points.

The pulse duration is the difference between the start of impact time and the time when the G level falls below 0 G on the falling side of the impact profile for the first time.

The onset rate (slope) is calculated based on the point at 20% of the peak G level and the point at 80% of the peak G level on the rising side of the impact profile. The software searches for the point at 80% of the peak G level starting at the beginning of the impact profile. The program searches for the point at 20% of the peak G level, starting at the peak G level and searching backwards.

Two different definitions were used for the rise time depending on the cell type, which are different than what is normally used in the Biodynamic Data Bank. In the Biodynamic Data Bank, the rise time is calculated using the time at the peak G level attained in a test, regardless of the form of the acceleration profile. The method used here for nonsinusoidal acceleration profiles, such as trapezoids, was judged to be better because the slope of the pulse indicated approximately by the rise time will correspond more closely to the onset rate if the peak acceleration appears late in the pulse. For approximately sinusoidal pulses, the method used here was judged to be better because often there are high-frequency oscillations superimposed on the sinusoid of the acceleration profile which can affect the calculated rise time.

The following definition was used for cells E,F,G,H,R,U,V,N,O,L,M (i.e., generally non-sinusoidal pulse profiles) to calculate the rise time:

A line is drawn through the 0.2 G point and the point at 90% of the peak G level on the rising side of the impact profile. The line is extended upward to the peak G level. The rise time is the difference between the time when the line reaches the peak G level and the time when the G level is 0.2 G. Figure 3 is a graphical representation of this procedure.

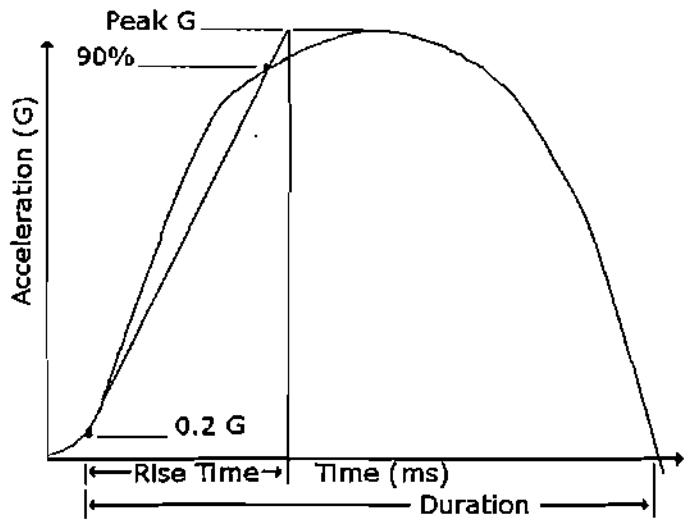

Figure 3. Rise Time Calculation for Non-sinusoidal Pulses

For all other cells (i.e. sinusoidal pulse profiles), the following rise time definition was used:

The times at 95% of peak G on both sides of the time of peak G are averaged. The rise time is the difference between this average time and the start of impact time (0.2 G). Figure 4 is a graphical representation of this procedure.

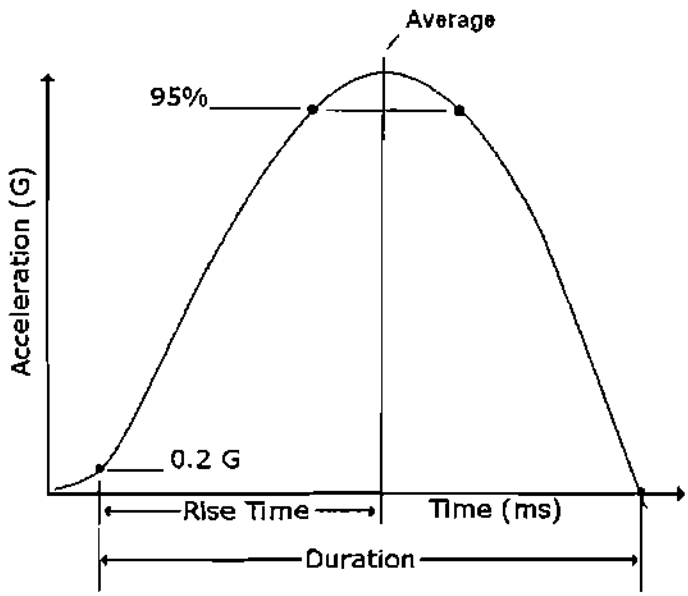

Figure 4. Rise Time Calculation for Sinusoidal Pulses

Table 4. Pin Response Characteristics

CELL	PIN	PEAK G	VELOCITY CHANGE ft/sec	ONSET RATE g/sec	RISE TIME ms	PULSE DURATION ms
A	1	9	18.9	297	42	100
B	1	20	35.2	746	37	85
C	1	30	43.1	1198	36	74
D	1	40	54.4	1679	34	70
E	2	10	50.4	250	47	221
F	2	20	76.1	522	55	168
G	2	30	93.9	832	49	140
H	2	40	108.6	1073	54	126
I	3	30	75.3	521	60	126
J	3	20	51.7	294	65	134
K	3	10	30.3	374	71	140
L	4	10	45.4	594	71	231
M	4	10	28.2	723	26	118
N	5	10	12.6	935	15	71
O	5	10	41.0	1127	15	229
P	6	10	28.2	1828	72	118
Q	6	10	51.5	85	132	240
R	2	30	53.6	1191	30	79
S	24	10	33.4	129	87	140
T	24	10	52.4	61	174	261
U	22	20	33.2	1800	17	82
V	22	20	70.3	1415	35	171
W	7	10	4.0	2098	9	35
X	8	10	7.9	726	22	50
Y	9	10	16.5	531	30	87
Z	10	10	17.4	436	35	87

Table 4. HIA Pin Response Characteristics (continued)

CELL	PIN	PEAK G	VELOCITY CHANGE ft/sec	ONSET RATE G/sec	RISE TIME ms	PULSE DURATION ms
AA	11	10	31.4	154	74	157
BB	12	10	50.8	88	117	248
DD	14	10	13.7	1157	14	78
EE	15	10	14.8	1037	16	89
FF	16	10	15.4	899	20	84
GG	17	10	16.3	794	23	87
II	19	10	41.2	93	110	201
JJ	20	10	15.0	1236	15	88
KK	21	10	15.2	990	14	78
LL	23	10	34.3	132	82	165
MM	13	10	58.0	69	160	249
NN	18	10	58.5	71	160	248
OO	51	10	20.0	214	55	98
PP	52	10	43.4	99	112	205
QQ	53	13	35.6	3082	7	127
RR	62	11	26.3	179	61	105
SS	63	7	16.3	1550	8	128
TT	73	10	33.8	135	77	161
UU	74	11	27.6	215	63	107
VV	9	6	12.6	351	32	105
WW	10	6	12.6	273	38	105
XX	11	6	23.8	94	84	190
YY	19	6	31.1	49	130	246
ZZ	23	6	24.0	64	100	208

DISCUSSION

For most cells in this test program, set length was generally set greater than or equal to load length due to time restraints. It is possible to reduce the set length below this, which will reduce the pulse duration further and slightly reduce the rise time. This is useful for fine tuning a pulse to achieve a more nearly perfect sinusoidal profile.

Some operating limitations of the HIA that must be kept in mind include:

a.) maximum set length = 168 in
b.) minimum set length = pulse duration stroke length (calculated by the computer program used to determine HIA operating characteristics)
c.) maximum load length = 116 in
d.) minimum load length = pin length + 3 in
e.) ratio of load pressure/set pressure = 6 maximum
f.) maximum operating pressure = 3,000 psi
g.) maximum surge pressure = 5,000 psi
h.) maximum sled payload weight = 2,500 lbs

CONCLUSIONS

The data collected in this study will enable researchers to quickly determine, by means of easy-to-use tables, if the Horizontal Impulse Accelerator has the capability to meet the acceleration profile requirements of their test program. The data will be stored in the Biodynamic Data Bank, thereby closing a gap in its coverage of HIA response characteristics.

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Cheng H., Mosher S.E., and Buhrman J.R., 2004. "Development and Use of the Biodynamics Data Bank and its Web Interface". Armstrong Laboratory Technical Report AFRL-HE-WP-TR-2004-0147.

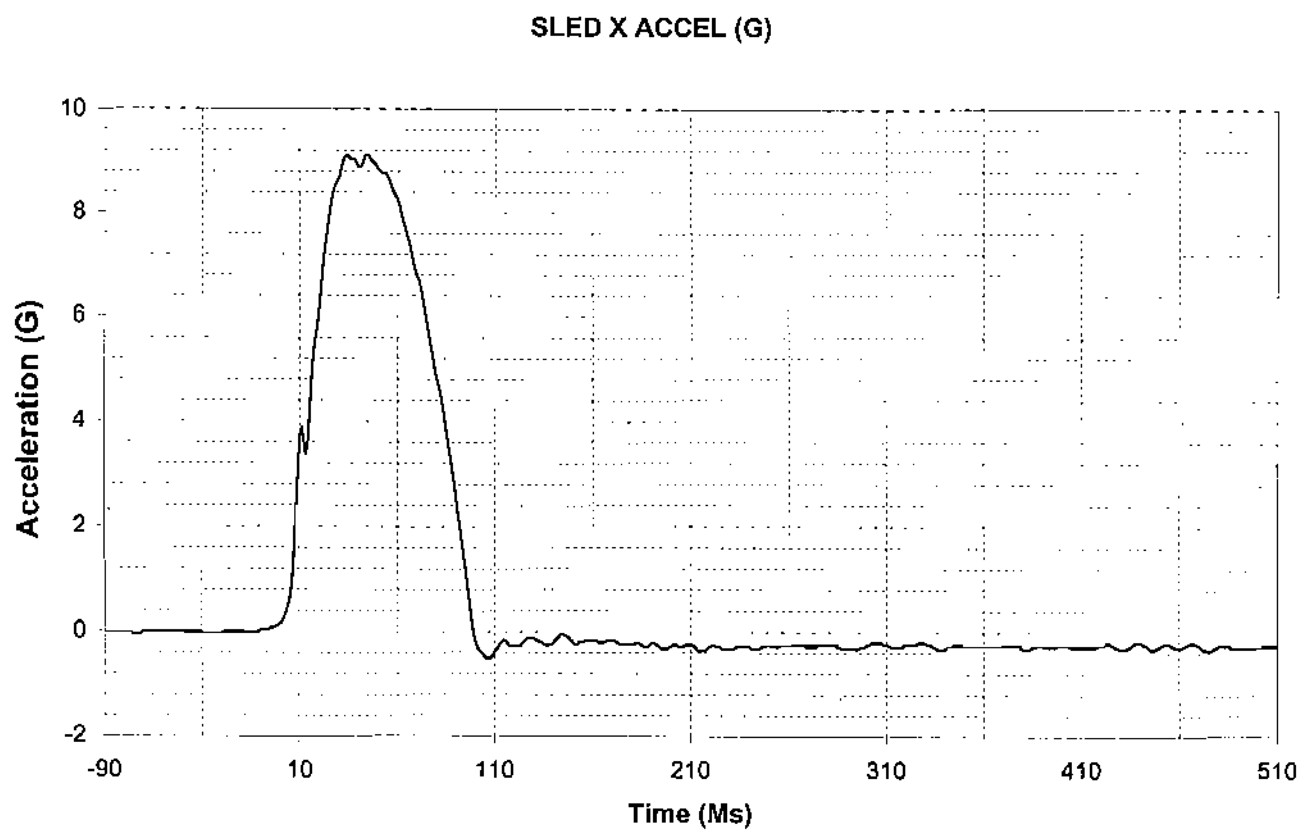
APPENDIX A

Test Data

HPROF Study Test: 7784 Test Date: 050303 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: A

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-98.0	
Impact Rise Time (Ms)				42.3	
Impact Duration (Ms)				100.0	
Velocity Change (Ft/Sec)		18.88			
SLED X ACCEL (G)	0.00	9.12	-0.52	34.0	106.0
SLED Y ACCEL (G)	0.01	1.91	-0.56	40.0	47.0
SLED Z ACCEL (G)	0.94	1.87	0.43	15.0	23.0
SLED VELOCITY (FT/SEC)	1.54	20.45	1.54	93.0	0.0
ONSET RATE (G/SEC)		296.69		24.0	9.4

HPROF Study Test: 7784 Test Date: 050303 Subj: VIP-95 Cell: A Pin Number: 1



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HPROF Study Test: 7789 Test Date: 050303 Subj: VIP-95 Wt: 212.0
Nom G: 20.0 Cell: B

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-127.0	
Impact Rise Time (Ms)				37.1	
Impact Duration (Ms)				85.0	
Velocity Change (Ft/Sec)		35.19			
SLED X ACCEL (G)	0.00	20.56	-0.85	37.0	87.0
SLED Y ACCEL (G)	0.05	3.05	-1.23	34.0	41.0
SLED Z ACCEL (G)	0.95	3.10	0.01	46.0	86.0
SLED VELOCITY (FT/SEC)	1.28	36.59	1.33	85.0	0.0
ONSET RATE (G/SEC)		746.43		23.5	8.2

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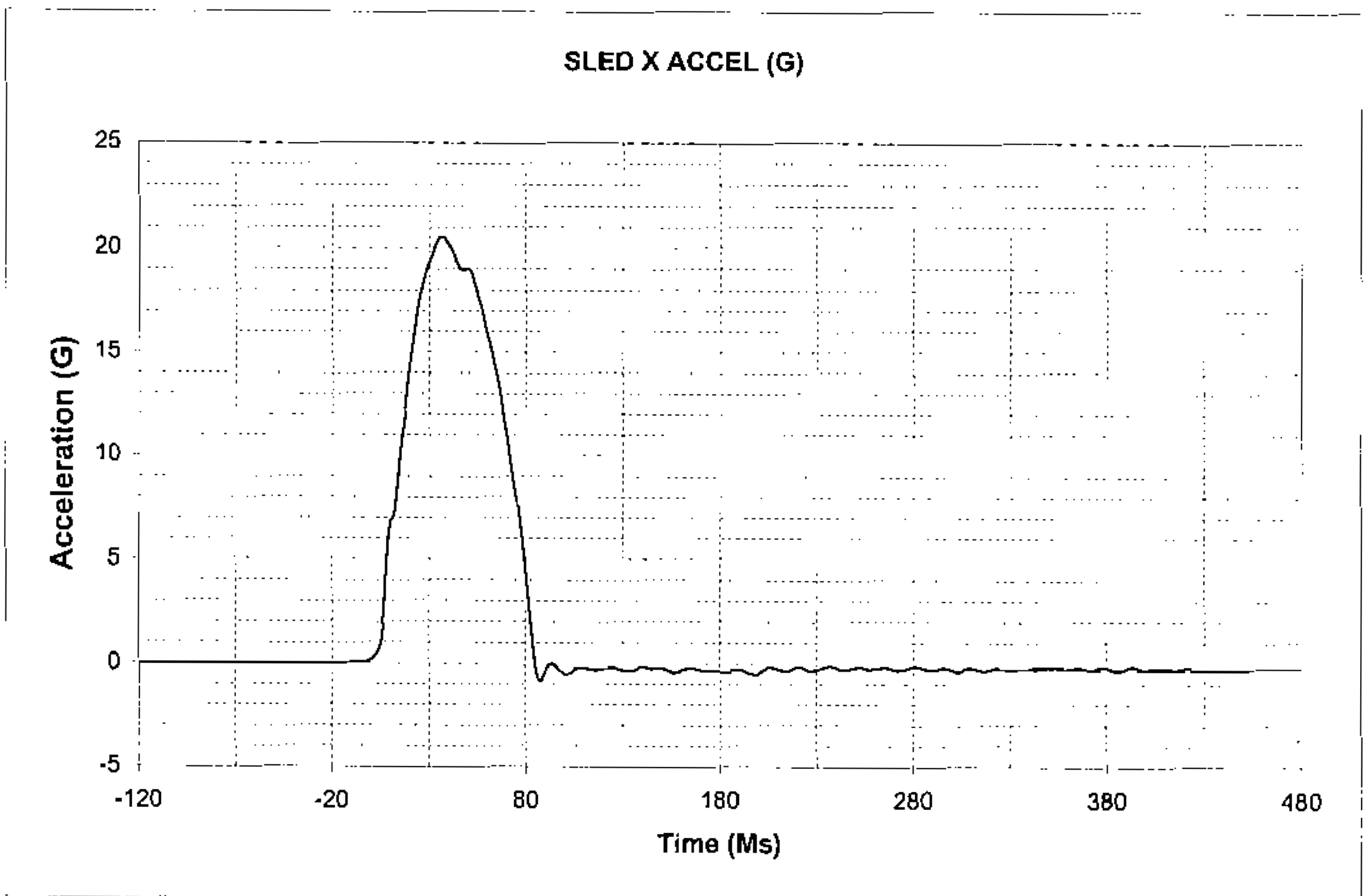
HPROF Study Test: 7789 Test Date: 050303 Subj: VIP-95 Cell: B Pin Number: 1



HPROF Study Test: 7792 Test Date: 050303 Subj: VIP-95 Wt: 212.0
Nom G: 30.0 Cell: C

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-180.0	
Impact Rise Time (Ms)				35.7	
Impact Duration (Ms)				74.0	
Velocity Change (Ft/Sec)		43.09			
SLED X ACCEL (G)	0.02	30.04	-0.85	37.0	76.0
SLED Y ACCEL (G)	0.00	3.30	-1.60	31.0	39.0
SLED Z ACCEL (G)	1.00	3.31	-0.15	42.0	9.0
SLED VELOCITY (FT/SEC)	1.30	44.55	1.34	159.0	0.0
ONSET RATE (G/SEC)		1197.74		22.4	7.4

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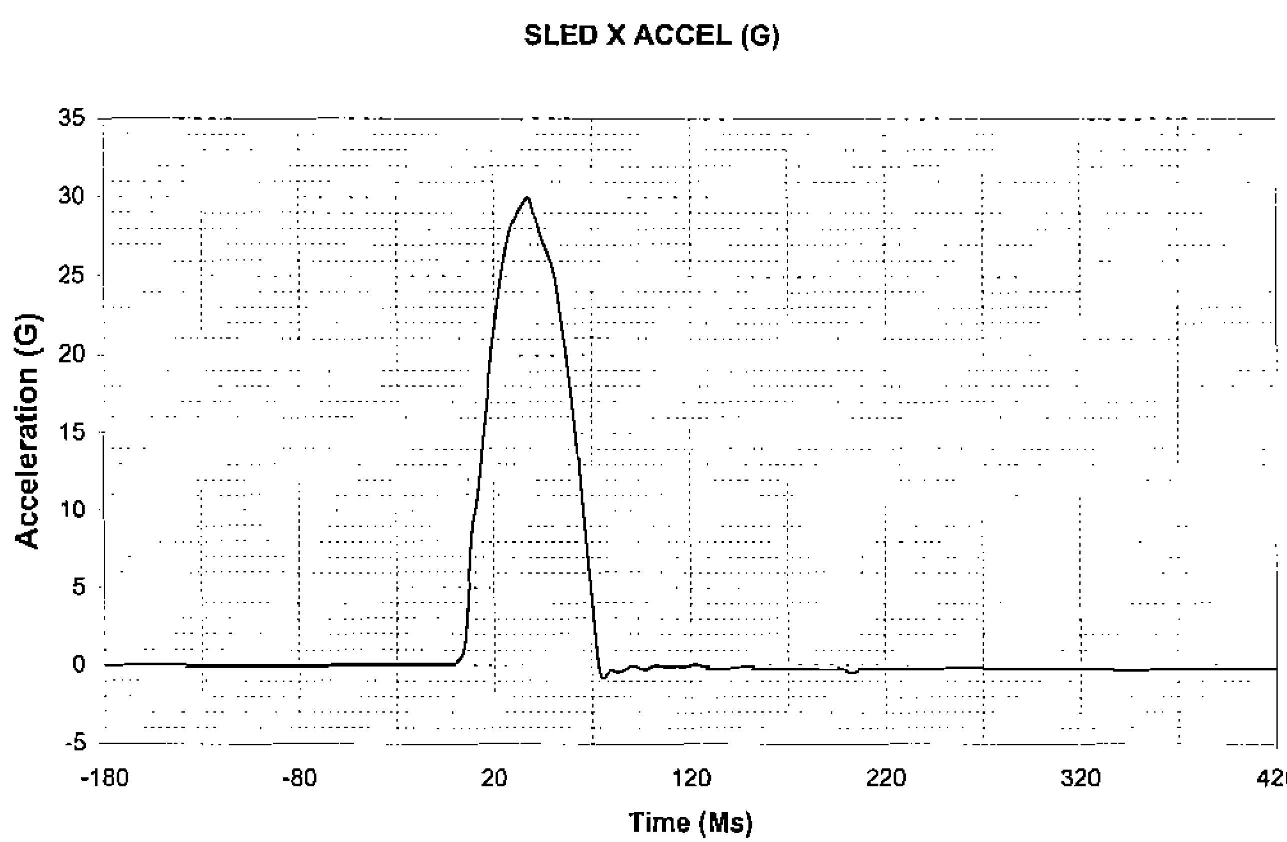
HPROF Study Test: 7792 Test Date: 050303 Subj: VIP-95 Cell: C Pin Number: 1



HPROF Study Test: 7794 Test Date: 050304 Subj: VIP-95 Wt: 212.0
Nom G: 40.0 Cell: D

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-253.0	
Impact Rise Time (Ms)				34.1	
Impact Duration (Ms)				70.0	
Velocity Change (Ft/Sec)		54.43			
SLED X ACCEL (G)	0.01	40.50	-1.17	36.0	71.0
SLED Y ACCEL (G)	0.00	3.04	-1.46	29.0	22.0
SLED Z ACCEL (G)	1.00	3.59	-1.18	34.0	76.0
SLED VELOCITY (FT/SEC)	1.49	57.19	1.54	104.0	0.0
ONSET RATE (G/SEC)		1679.43		21.7	7.3

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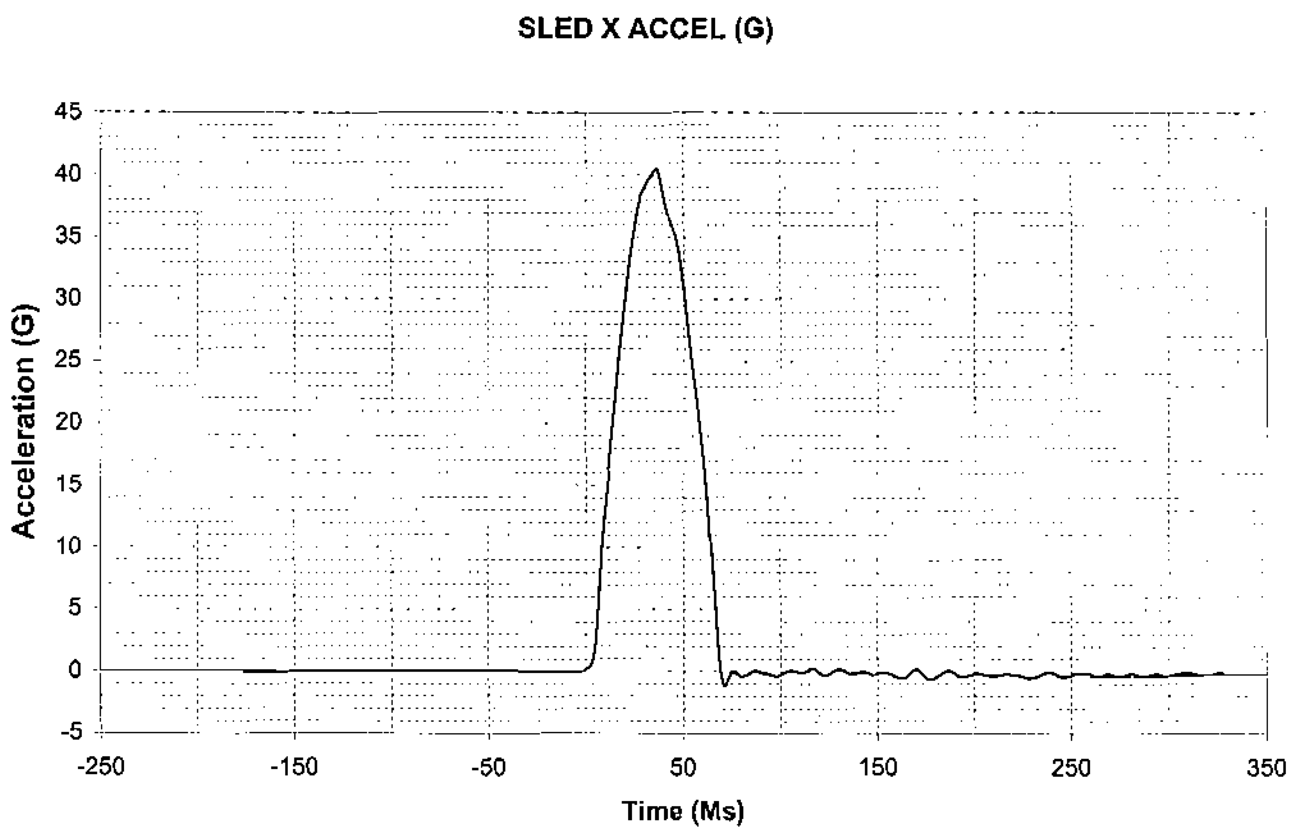
HPROF Study Test: 7794 Test Date: 050304 Subj: VIP-95 Cell: D Pin Number: 1



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HPROF Study Test: 7795 Test Date: 050308 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: E

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-158.0	
Impact Rise Time (Ms)				46.6	
Impact Duration (Ms)				221.0	
Velocity Change (Ft/Sec)		50.39			
SLED X ACCEL (G)	0.01	10.97	-0.52	77.0	233.0
SLED Y ACCEL (G)	0.00	1.56	-0.56	42.0	88.0
SLED Z ACCEL (G)	1.00	2.30	0.11	14.0	23.0
SLED VELOCITY (FT/SEC)	1.47	53.47	1.47	226.0	0.0
ONSET RATE (G/SEC)		249.53		33.2	6.9

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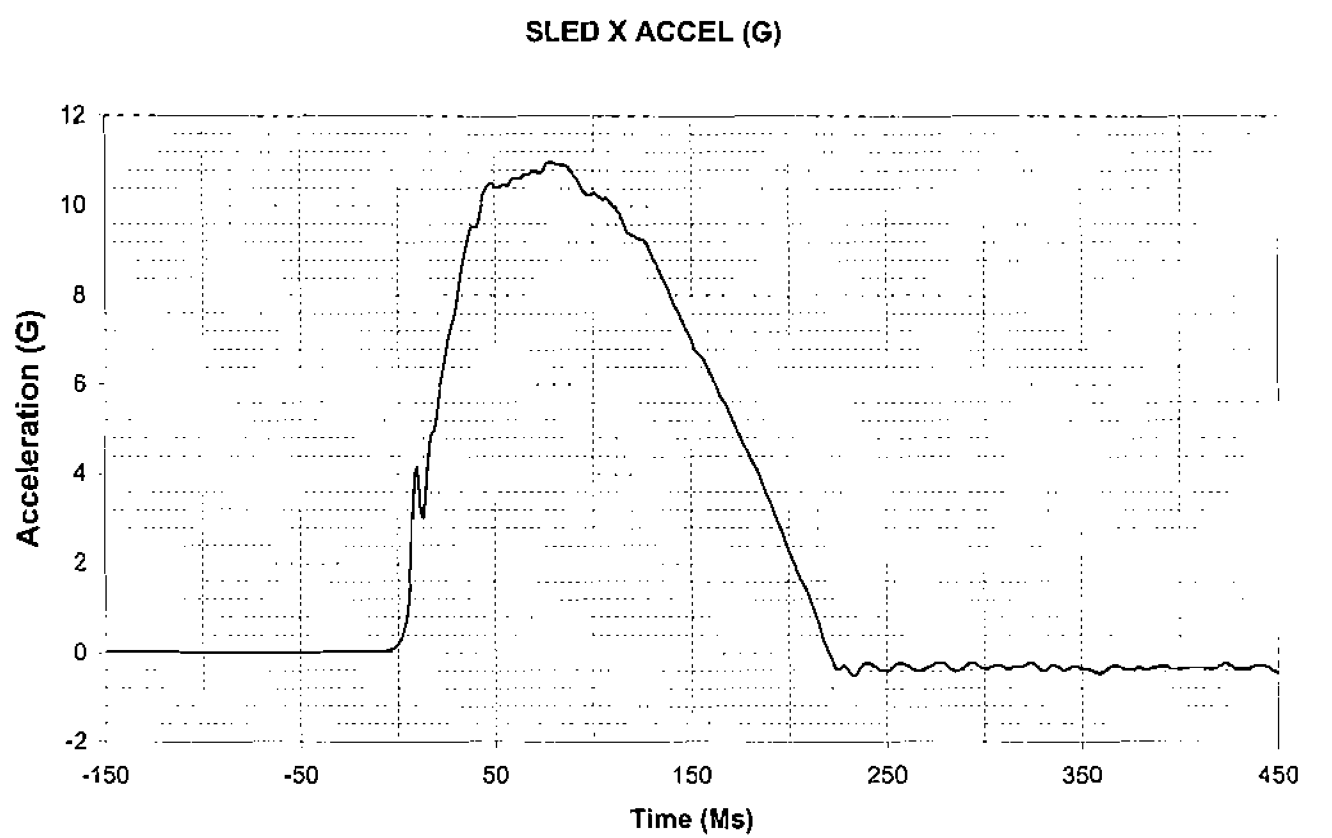
HPROF Study Test: 7795 Test Date: 050308 Subj: VIP-95 Cell: E Pin Number: 2



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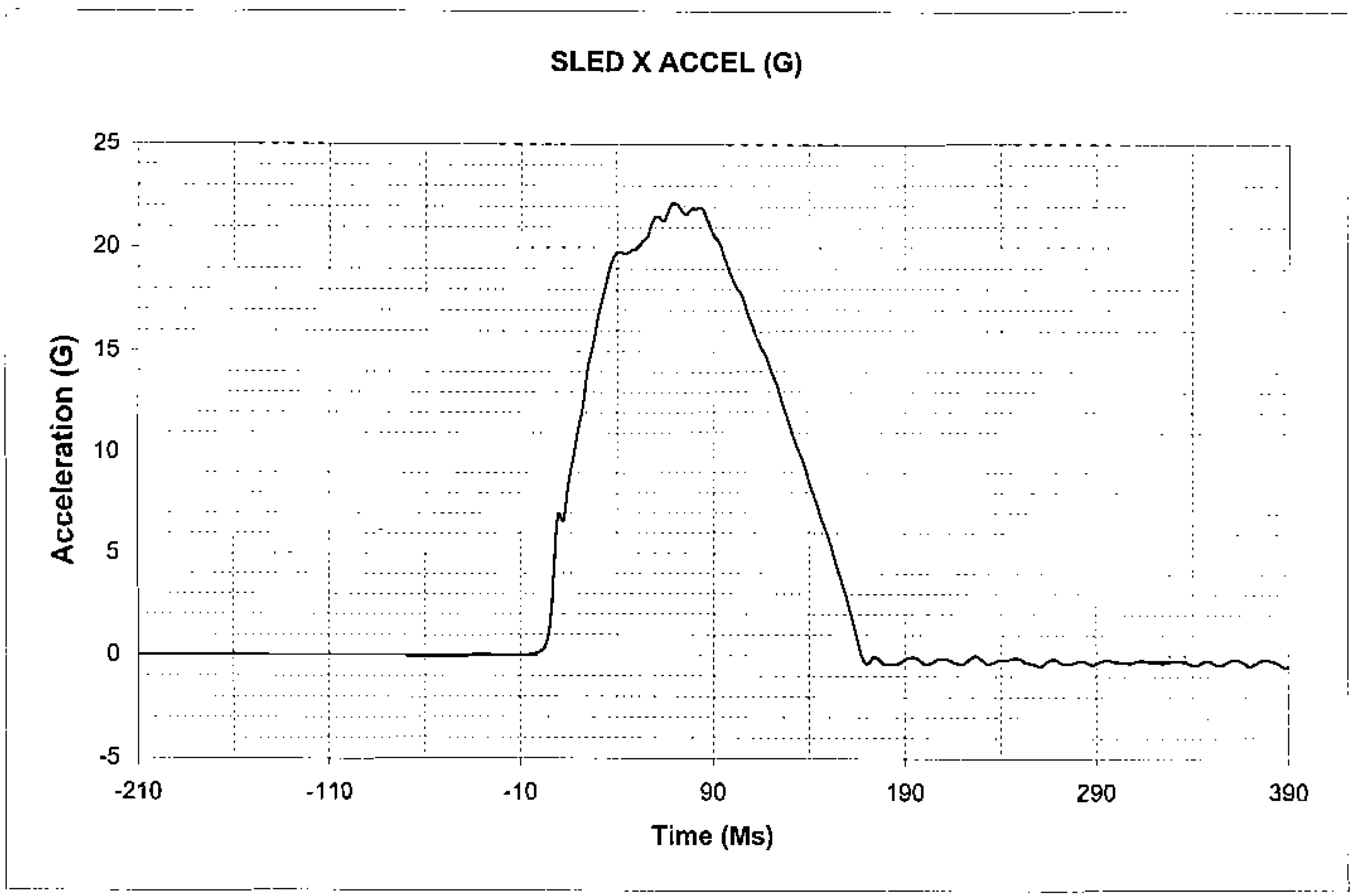
HPROF Study Test: 7796 Test Date: 050308 Subj: VIP-95 Wt: 212.0
Nom G: 20.0 Cell: F

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-214.0	
Impact Rise Time (Ms)				54.7	
Impact Duration (Ms)				168.0	
Velocity Change (Ft/Sec)		76.11			
SLED X ACCEL (G)	0.00	22.16	-0.55	69.0	388.0
SLED Y ACCEL (G)	0.00	2.30	-1.29	36.0	44.0
SLED Z ACCEL (G)	1.00	3.08	-0.11	76.0	166.0
SLED VELOCITY (FT/SEC)	1.52	79.49	1.52	167.0	0.0
ONSET RATE (G/SEC)		522.01		32.6	7.2

HPROF Study Test: 7796 Test Date: 050308 Subj: VIP-95 Cell: F Pin Number: 2



HPROF Study Test: 7797 Test Date: 050308 Subj: VIP-95 Wt: 212.0
Nom G: 30.0 Cell: G

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-312.0	
Impact Rise Time (Ms)				48.8	
Impact Duration (Ms)				140.0	
Velocity Change (Ft/Sec)		93.92			
SLED X ACCEL (G)	-0.01	32.89	-0.99	68.0	143.0
SLED Y ACCEL (G)	0.00	2.42	-1.31	33.0	40.0
SLED Z ACCEL (G)	1.00	4.00	0.24	75.0	80.0
SLED VELOCITY (FT/SEC)	1.54	34.96	1.58	294.0	0.0
ONSET RATE (G/SEC)		831.97		30.4	6.7

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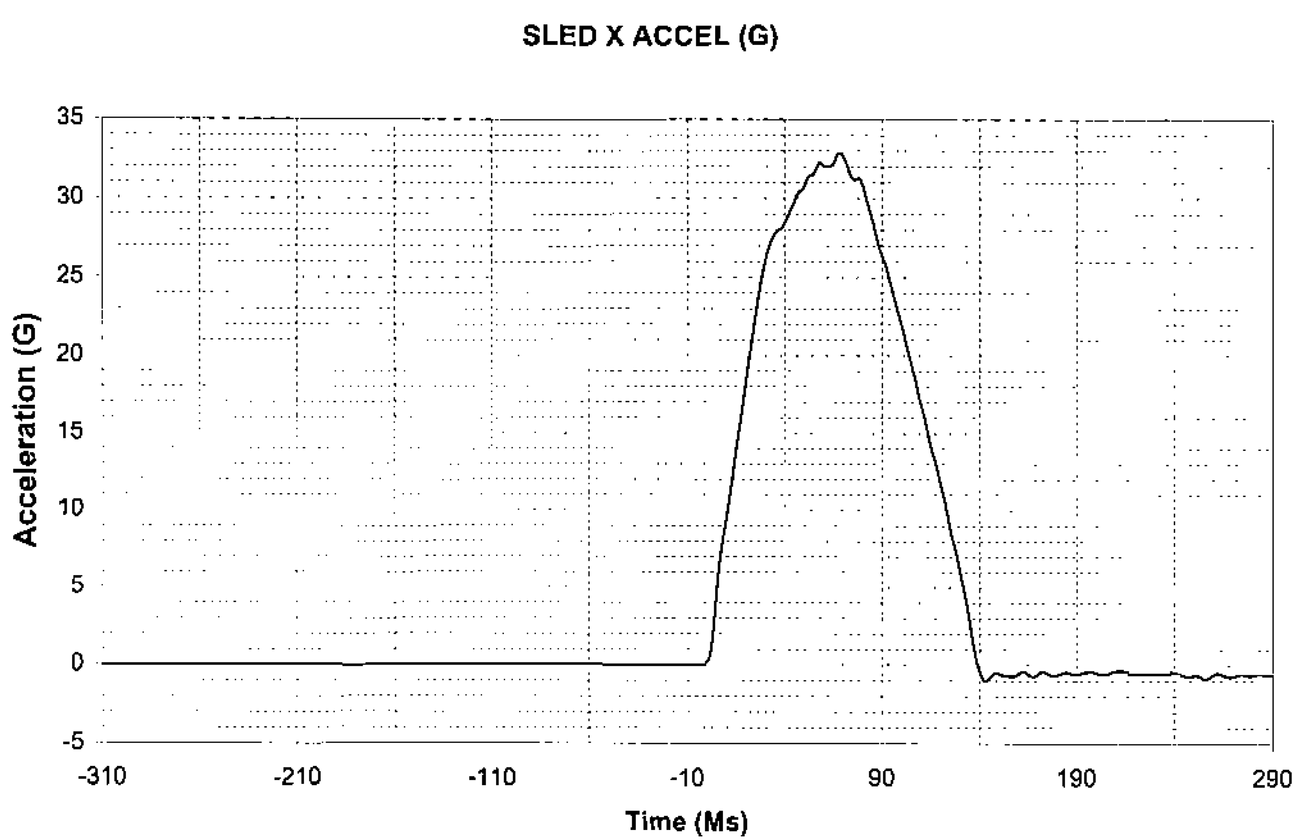
HPROF Study Test: 7797 Test Date: 050308 Subj: VIP-95 Cell: G Pin Number: 2



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HPROF Study Test: 7799 Test Date: 050310 Subj: VIP-95 Wt: 212.0
Nom G: 40.0 Cell: H

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-350.0	
Impact Rise Time (Ms)				54.1	
Impact Duration (Ms)				126.0	
Velocity Change (Ft/Sec)		108.65			
SLED X ACCEL (G)	0.02	44.00	-0.87	58.0	128.0
SLED Y ACCEL (G)	0.00	2.82	-1.59	33.0	41.0
SLED Z ACCEL (G)	1.00	5.15	0.27	70.0	76.0
SLED VELOCITY (FT/SEC)	1.46	1.56	1.31	42.0	38.0
ONSET RATE (G/SEC)		1072.57		34.7	10.1

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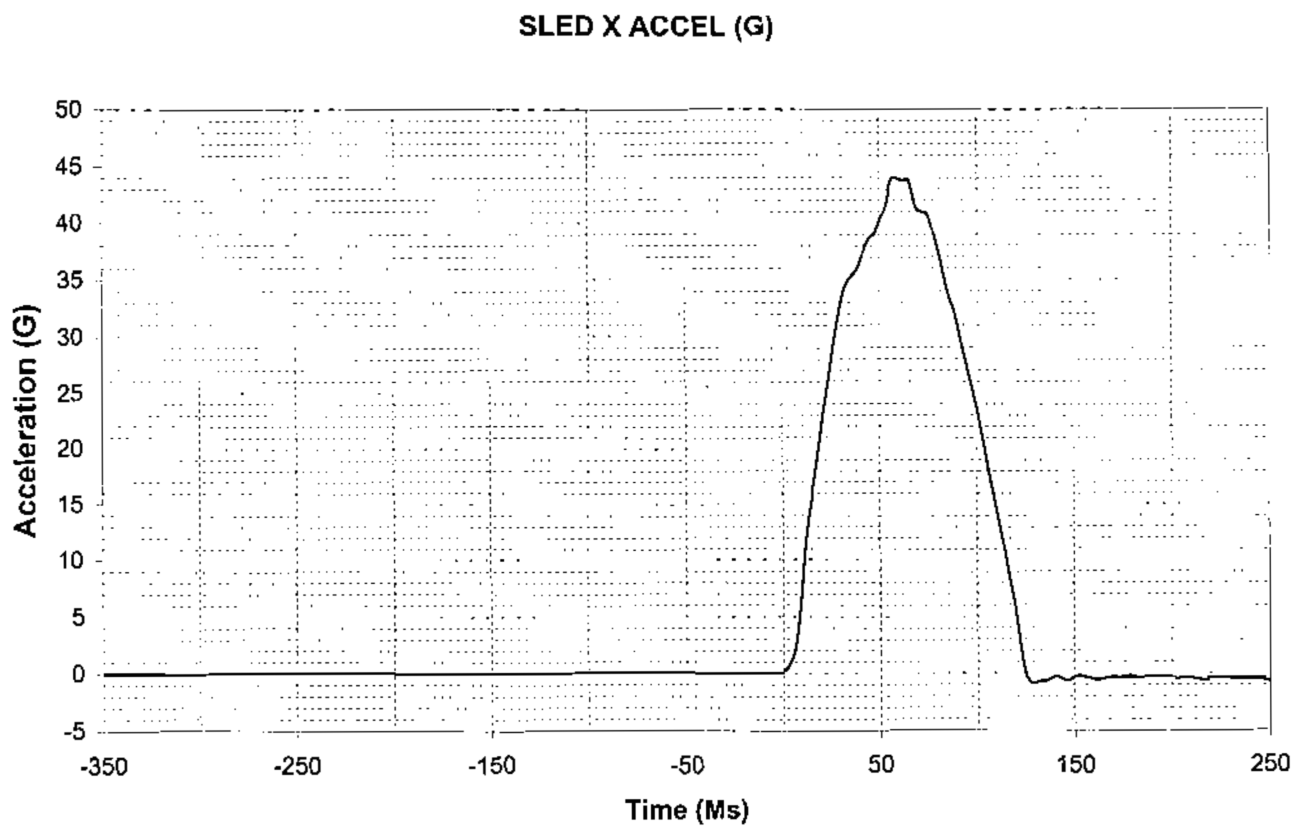
HPROF Study Test: 7799 Test Date: 050310 Subj: VIP-95 Cell: H Pin Number: 2



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HPROF Study Test: 7803 Test Date: 050311 Subj: VIP-95 Wt: 212.0
Nom G: 30.0 Cell: J

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-339.0	
Impact Rise Time (Ms)				59.6	
Impact Duration (Ms)				126.0	
Velocity Change (Ft/Sec)		75.32			
SLED X ACCEL (G)	0.00	32.23	-0.98	58.0	128.0
SLED Y ACCEL (G)	0.00	3.51	-1.29	32.0	53.0
SLED Z ACCEL (G)	1.00	3.27	-0.08	44.0	9.0
SLED VELOCITY (FT/SEC)	1.44	1.54	1.39	42.0	128.0
ONSET RATE (G/SEC)		520.89		45.0	7.8

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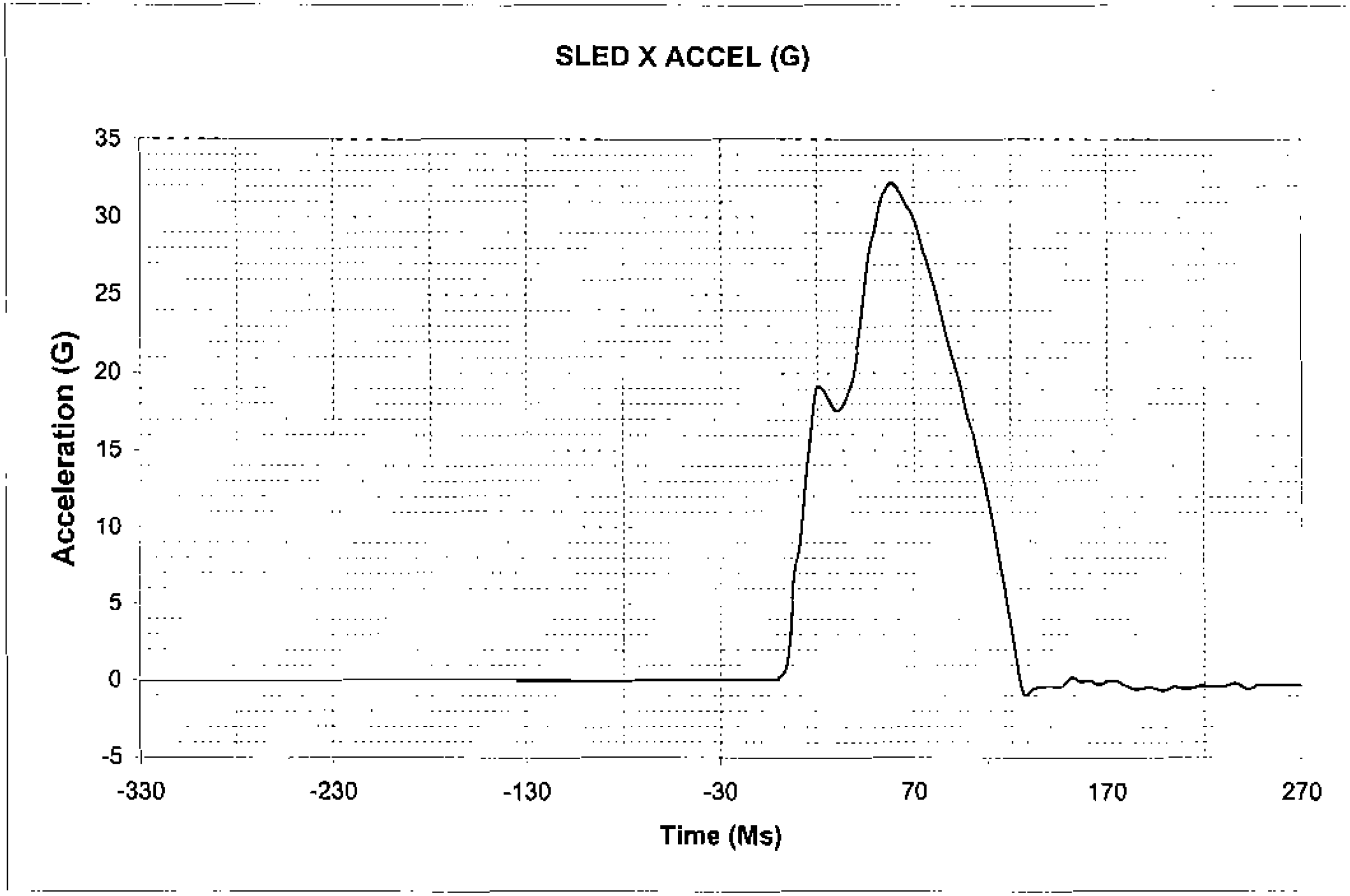
HPROF Study Test: 7803 Test Date: 050311 Subj: VIP-95 Cell: I Pin Number: 3



HPROF Study Test: 7802 Test Date: 050311 Subj: VIP-95 Wt: 212.0
Nom G: 20.0 Cell: J

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-271.0	
Impact Rise Time (Ms)				65.0	
Impact Duration (Ms)				134.0	
Velocity Change (Ft/Sec)		51.67			
SLED X ACCEL (G)	0.01	19.99	-0.63	63.0	137.0
SLED Y ACCEL (G)	-0.01	2.67	-0.79	36.0	43.0
SLED Z ACCEL (G)	1.00	2.35	0.31	72.0	10.0
SLED VELOCITY (FT/SEC)	1.71	1.81	1.66	62.0	135.0
ONSET RATE (G/SEC)		293.61		49.6	8.8

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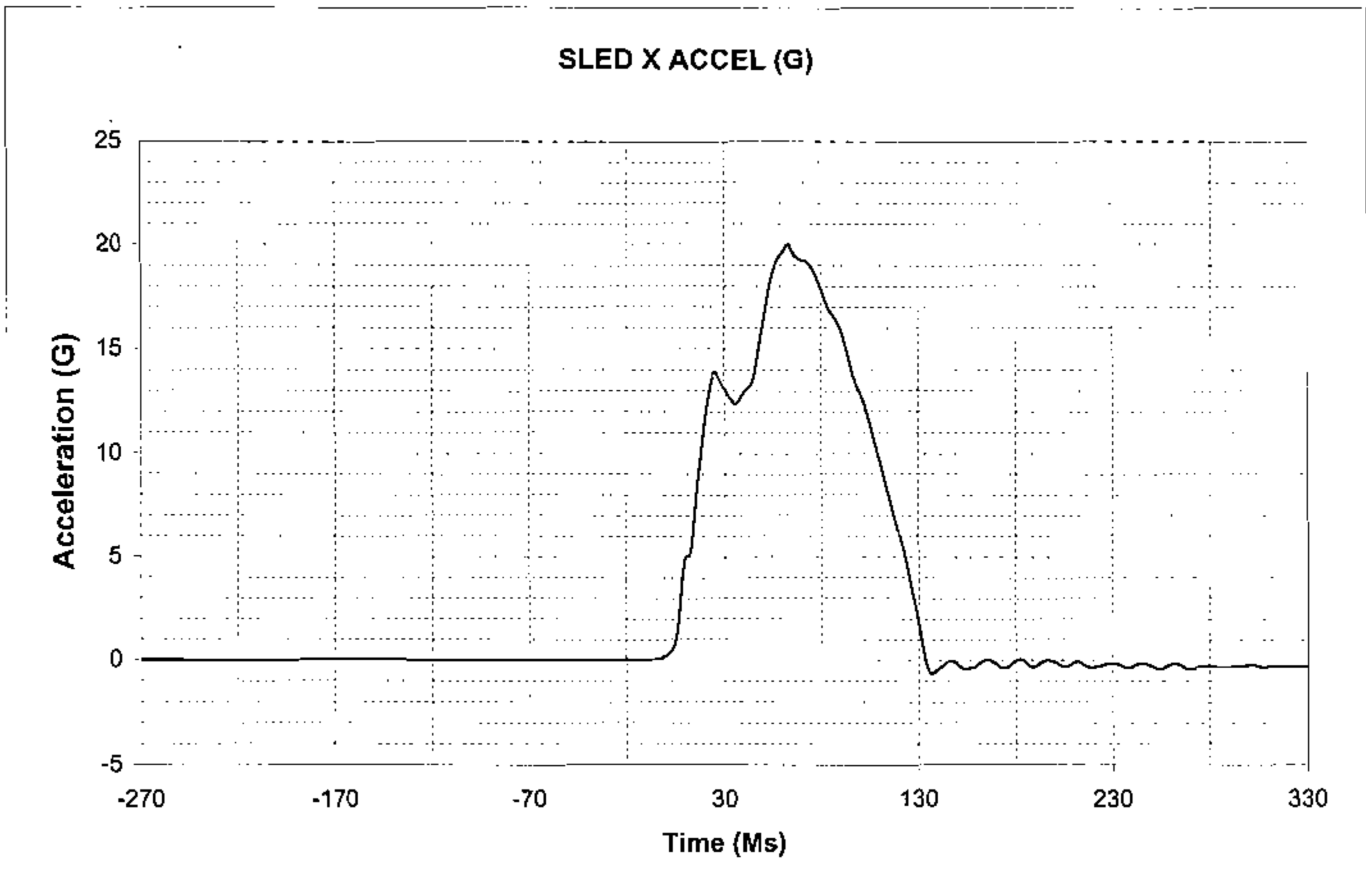
HPROF Study Test: 7802 Test Date: 050311 Subj: VIP-95 Cell: J Pin Number: 3



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HPROF Study Test: 7801 Test Date: 050311 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: K

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-208.0	
Impact Rise Time (Ms)				70.7	
Impact Duration (Ms)				140.0	
Velocity Change (Ft/Sec)		30.33			
SLED X ACCEL (G)	0.02	10.75	-0.39	69.0	148.0
SLED Y ACCEL (G)	0.00	1.82	-0.59	42.0	71.0
SLED Z ACCEL (G)	1.00	1.92	0.66	15.0	152.0
SLED VELOCITY (FT/SEC)	1.49	1.64	1.44	81.0	26.0
ONSET RATE (G/SEC)		374.10		26.0	8.8

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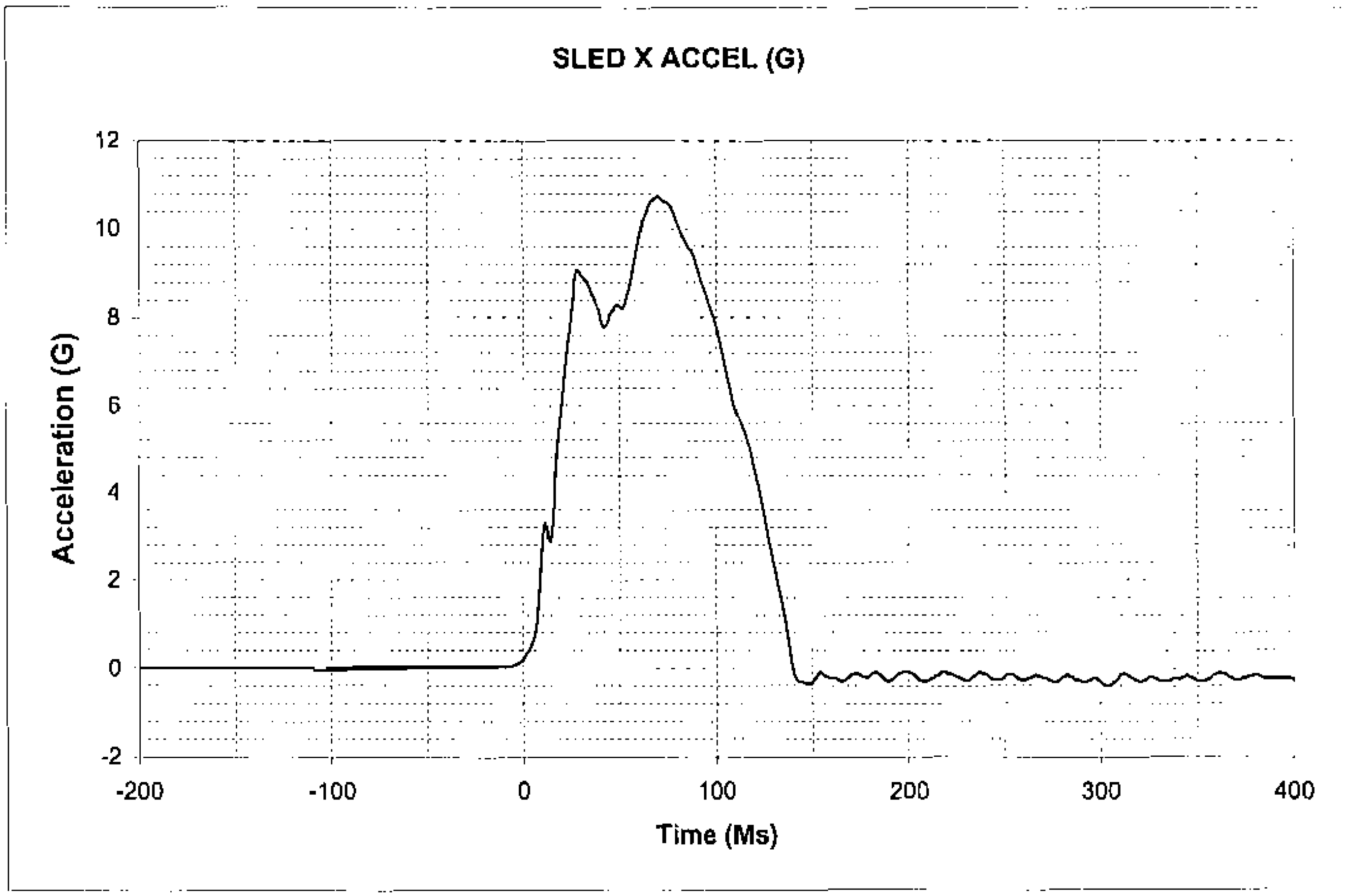
HPROF Study Test: 7801 Test Date: 050311 Subj: VIP-95 Cell: K Pin Number: 3



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HPROF Study Test: 7817 Test Date: 050323 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: L

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-214.0	
Impact Rise Time (Ms)				70.9	
Impact Duration (Ms)				231.0	
Velocity Change (Ft/Sec)		45.40			
SLED X ACCEL (G)	0.00	10.75	-0.55	95.0	241.0
SLED Y ACCEL (G)	0.00	1.72	-0.62	45.0	53.0
SLED Z ACCEL (G)	1.00	2.19	0.19	17.0	227.0
SLED VELOCITY (FT/SEC)	44.19	44.30	40.50	9.0	387.0
ONSET RATE (G/SEC)		593.56		21.3	10.4

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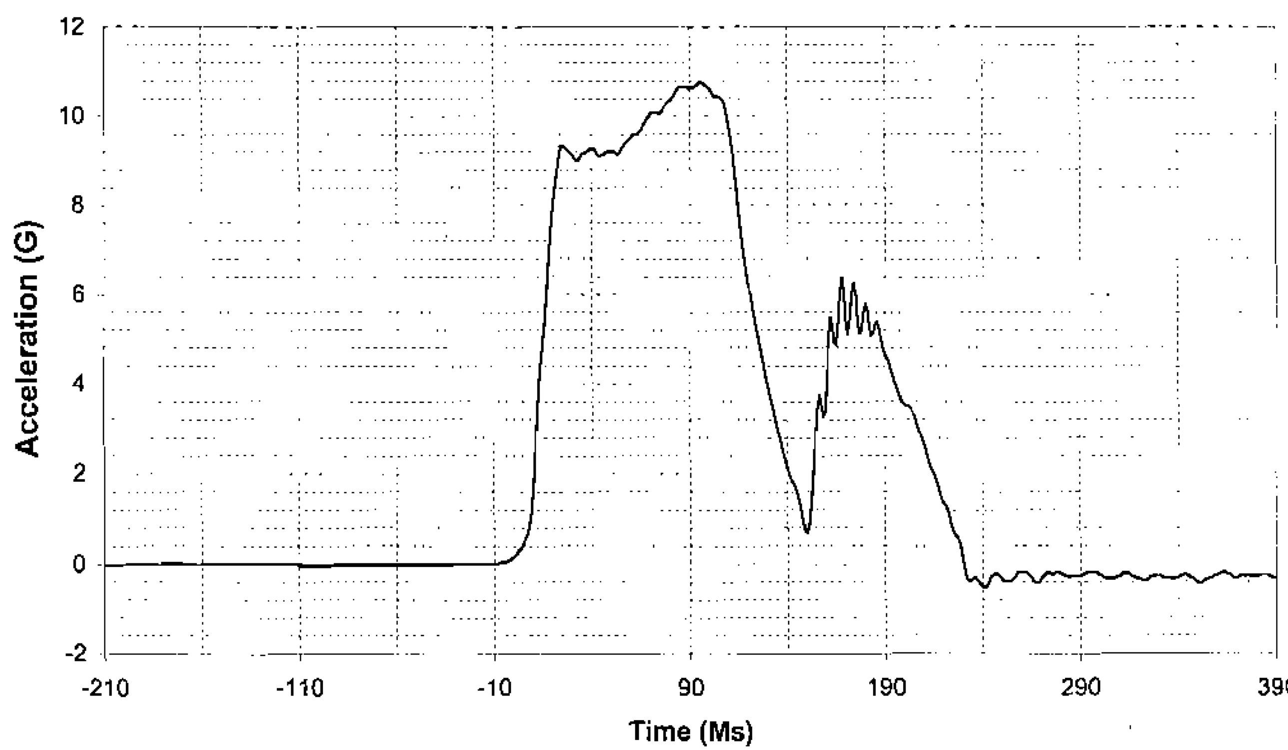
HPROF Study Test: 7817 Test Date: 050323 Subj: VIP-95 Cell: L Pin Number: 4

SLED X ACCEL (G)



HPROF Study Test: 7816 Test Date: 050323 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: M

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-163.0	
Impact Rise Time (Ms)				20.8	
Impact Duration (Ms)				118.0	
Velocity Change (Ft/Sec)		28.23			
SLED X ACCEL (G)	0.00	10.21	-0.50	22.0	121.0
SLED Y ACCEL (G)	0.00	1.78	-0.52	44.0	26.0
SLED Z ACCEL (G)	1.00	2.28	0.49	16.0	66.0
SLED VELOCITY (FT/SEC)	26.04	26.31	21.87	19.0	424.0
ONSET RATE (G/SEC)		722.80		17.1	8.7

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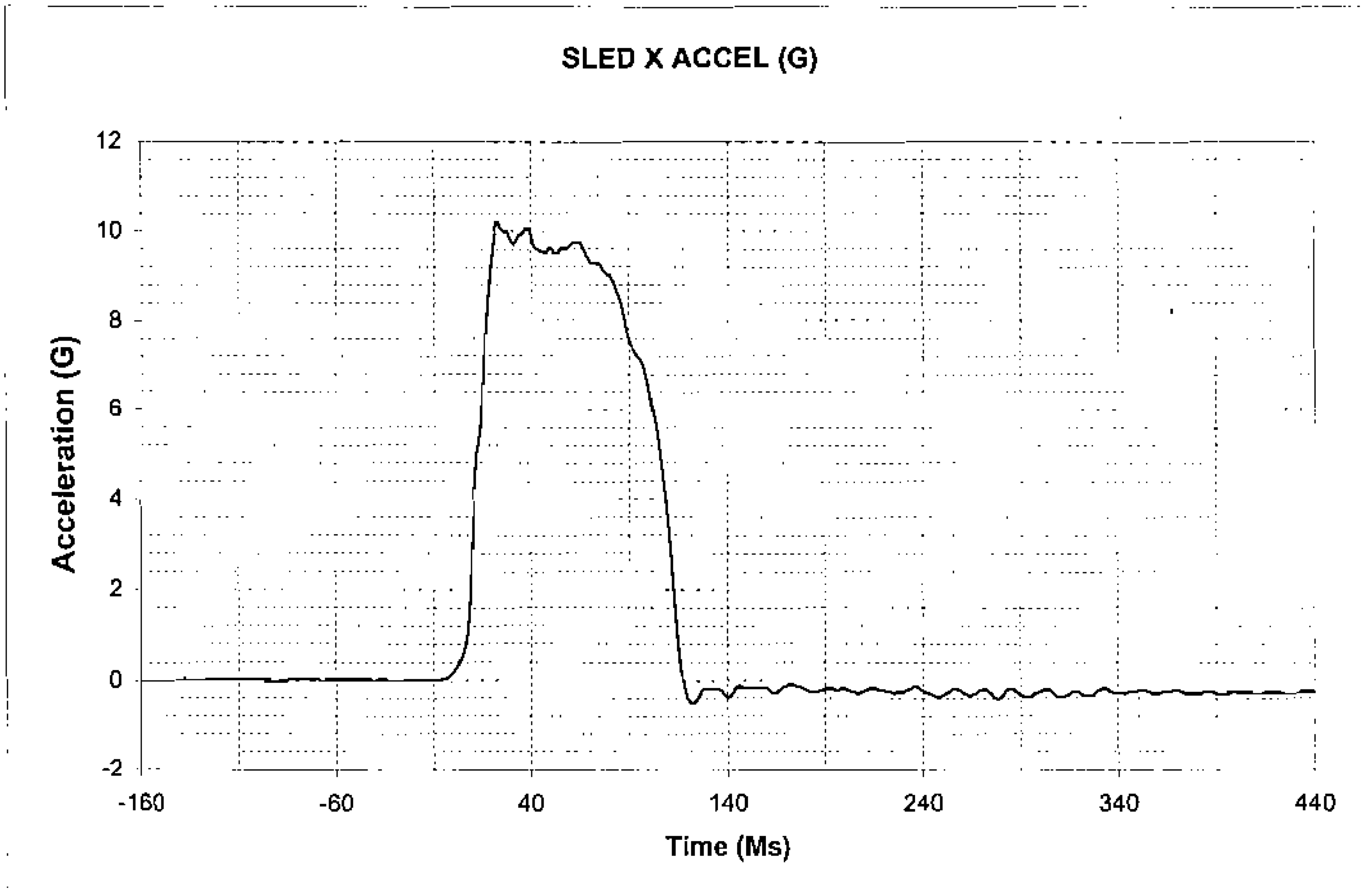
HPROF Study Test: 7816 Test Date: 050323 Subj: VIP-95 Cell: M Pin Number: 4



HPROF Study Test: 7812 Test Date: 050317 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: N

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-120.0	
Impact Rise Time (Ms)				14.7	
Impact Duration (Ms)				71.0	
Velocity Change (Ft/Sec)		12.60			
SLED X ACCEL (G)	-0.02	9.81	-0.38	17.0	75.0
SLED Y ACCEL (G)	-0.01	1.05	-0.53	43.0	23.0
SLED Z ACCEL (G)	0.98	2.10	0.44	14.0	65.0
SLED VELOCITY (FT/SEC)	1.42	1.42	1.42	0.0	0.0
ONSET RATE (G/SEC)		934.59		13.0	6.7

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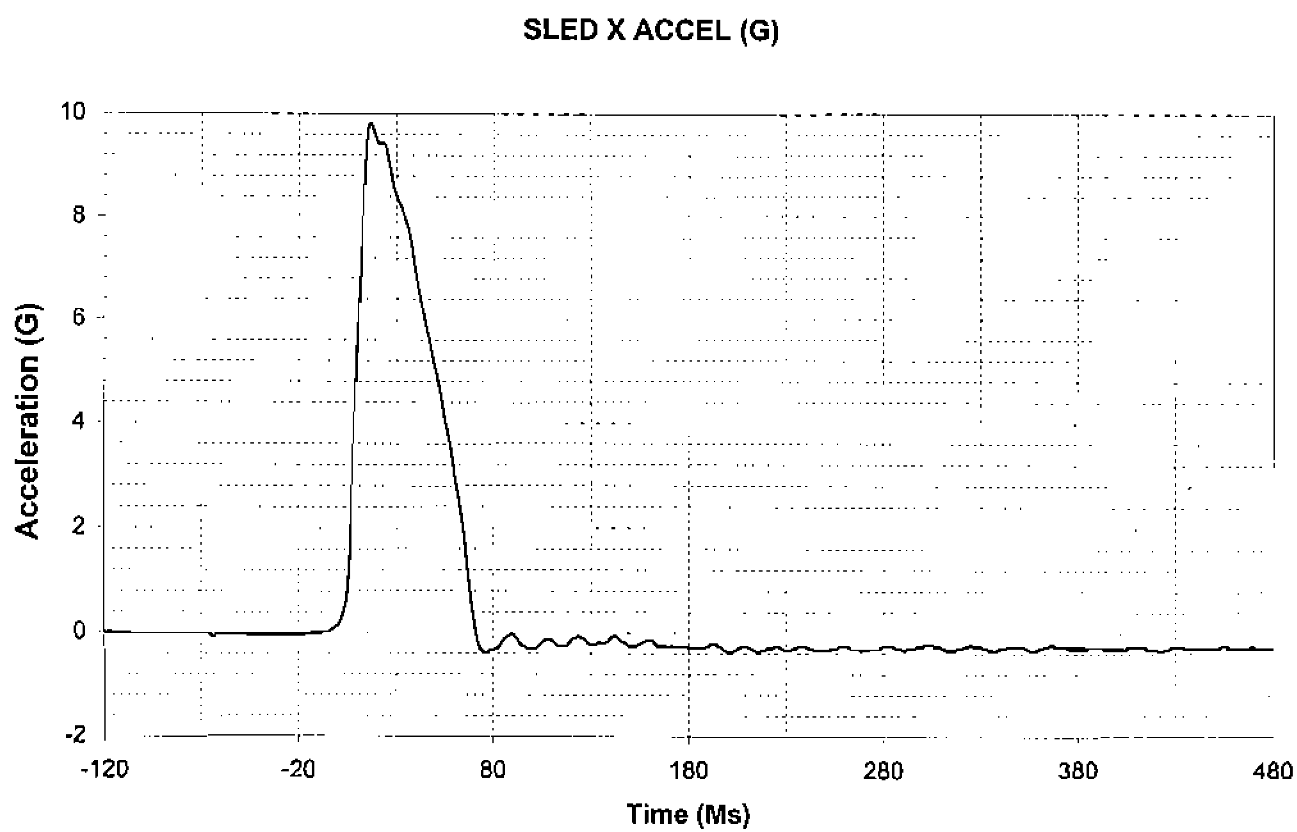
HPROF Study Test: 7812 Test Date: 050317 Subj: VIP-95 Cell: N Pin Number: 5



HPROF Study Test: 7813 Test Date: 050318 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: O

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-121.0	
Impact Rise Time (Ms)				14.6	
Impact Duration (Ms)				229.0	
Velocity Change (Ft/Sec)		41.01			
SLED X ACCEL (G)	-0.02	9.73	-0.26	16.0	233.0
SLED Y ACCEL (G)	0.00	1.83	-0.60	41.0	48.0
SLED Z ACCEL (G)	1.00	2.73	0.32	15.0	10.0
SLED VELOCITY (FT/SEC)	1.49	1.49	1.44	0.0	166.0
ONSET RATE (G/SEC)		1127.36		12.4	7.2

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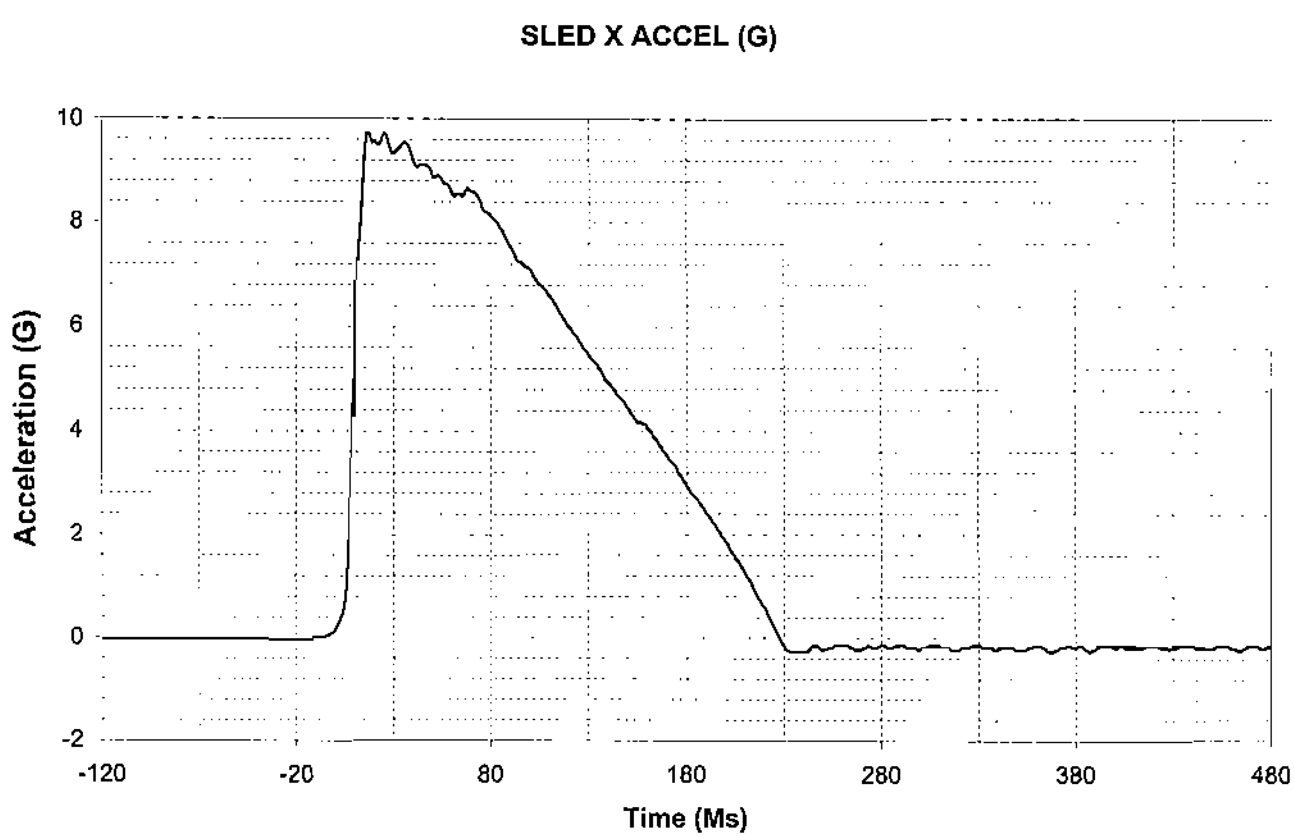
HPROF Study Test: 7813 Test Date: 050318 Subj: VIP-95 Cell: O Pin Number: 5



HPROF Study Test: 7815 Test Date: 050323 Subj: VIP-95 Wt: 212.0
Nom G: 10.0 Cell: P

Data ID	Immediate Preimpact	Maximum Value	Minimum Value	Time Of Maximum	Time Of Minimum
Reference Mark Time (Ms)				-270.0	
Impact Rise Time (Ms)				71.8	
Impact Duration (Ms)				118.0	
Velocity Change (Ft/Sec)		28.25			
SLED X ACCEL (G)	0.01	10.19	-0.83	67.0	120.0
SLED Y ACCEL (G)	0.00	1.01	-0.46	42.0	20.0
SLED Z ACCEL (G)	1.00	3.48	-0.40	14.0	9.0
SLED VELOCITY (FT/SEC)	1.55	1.55	1.55	0.0	0.0
ONSET RATE (G/SEC)		1828.22		8.4	5.1

HPROF Study Test: 7815 Test Date: 050323 Subj: VIP-95 Cell: P Pin Number: 6